REPORT ON EXISTING DATA AND DATA GAPS

D4.1

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TABLE OF CONTENT

LIST OF FIGURES 5
LIST OF TABLES 6
ACRONYMS & GLOSSARY 8
EXECUTIVE SUMMARY 11
1. Introduction 12
2. Lake Balaton and Kis-Balaton 14
2.1. Site description 14
2.2. Monitoring data 14
2.3. Campaign data 15
3. Curonian lagoon 17
3.1. Site description 17
3.2. Monitoring data 17
3.3. Campaign data 17
4. Mantua Lakes 20
4.1. Site description 20
4.2. Monitoring data 20
4.3. Campaign data 20
5. Venice lagoon 23
5.1. Site description 23
5.2. Monitoring data 23
5.3. Campaign data 23
6. Lake Constance 26
6.1. Site description 26
6.2. Available data 26
7. Gironde River 28
7.1. Site description 28
7.2. Monitoring 28
7.3. Campaigns 28
8. Scheldt River 30
8.1. Site description 30
8.2. Monitoring 30
8.3. Campaigns 30
9. Esthwaite Water 32
9.1. Site description 32
9.2. Monitoring data 32
9.3. Campaign data 32
10. Loch Leven 34
10.1. Site description 34
10.2. Monitoring data 34
10.3. Campaign data 34
11. IJsselmeer 36
11.1. Site description 36
11.2. Monitoring data 36
11.3. Campaign description 36

12. Lake Geneva 37
12.1. Site description 37
12.2. Monitoring data 37
12.3. Campaign data 37
13. LIMNADES 39
14. Gap analysis 40
15. Conclusion 44
Annex 1 45

LIST OF FIGURES

Figure 1. The location of the INFORM European study sites. 13
Figure 2. Geographic distribution of datasets contributed to LIMNADES. 39

LIST OF TABLES

Table 1. Overview of INFORM sites with their main characteristics. †Lake Geneva was added to the INFORM sites after discussions at the INFORM End-User Advisory Board meeting (EUAB01), Venice, March 2014. 12
Table 2. Overview of data collected at Lake Balaton and Kis-Balaton in 2010 available to the INFORM project for use in WP5 and WP6. 15
Table 3. Overview of data collected at Lake Balaton in 2013 available to the INFORM project for use in WP5 and WP6. 16
Table 4. Overview of data collected in the Curonian Lagoon in 2009 available to the INFORM project for use in WP5 and WP6. 18
Table 5. Overview of data collected in the Curonian Lagoon in 2011 available to the INFORM project for use in WP5 and WP6. 18
Table 6. Overview of data collected in the Curonian Lagoon in 2012 available to the INFORM project for use in WP5 and WP6. 19
Table 7. Overview of data collected at Mantua lakes in 2007 available to the INFORM project for use in WP5 and WP6. 21
Table 8. Overview of data collected at Mantua lakes in 2011 available to the INFORM project for use in WP5 and WP6. 21
Table 9. Overview of other data collected at Mantua Lakes available to the INFORM project for use in WP5 and WP6. 22
Table 10. Overview of data collected at Venice Lagoon in 2005 available to the INFORM project for use in WP5 and WP6. 24
Table 11. Overview of data collected at Venice Lagoon for seagrass spectral characterization available to the INFORM project for use in WP5 and WP6. 24
Table 12. Overview of data collected at Venice Lagoon in 2011-2012 available to the INFORM project for use in WP5 and WP6. 25
Table 13. Overview existing and to be used data for Lake Constance available to the INFORM project for use in WP5 and WP6. 26
Table 14. Overview of data collected at Gironde River in 2012 for use in WP5, Task 5.3 (*denotes data only available for use by other INFORM partners after approval by the host organization). 28
Table 15. Overview of data collected at Gironde River in 2013 for use in WP5, Task 5.3 (*denotes data only available for use by other INFORM partners after approval by the host organization). 29
Table 16. Overview of data collected at Scheldt river in 2010 for use in WP5, Task 5.3 3 (*denotes data only available for use by other INFORM partners after approval by the host organization). 31
Table 17. Overview of data collected at Scheldt river in 2012 for use in WP5, Task 5.3 3 (*denotes data only available for use by other INFORM partners after approval by the host organization). 31
Table 18. Overview of data collected at Esthwaite Water in 2007 available to the INFORM project for use in WP5 and WP6. 32
Table 19. Overview of data collected at Loch Leven in 2007 available to the INFORM project for use in WP5 and WP6. 34
Table 20. Overview of data collected at Lake Geneva available to the INFORM project for use in WP5 and WP6. 37

Table 21. Summary of the existing data available to the INFORM project. (NS = not specified; BGC = biogeochemical data). 42

ACRONYMS & GLOSSARY

a_{CDOM}: CDOM absorption coefficient
a_{NAP}: NAP absorption coefficient
a_p: Particulate absorption coefficient
a_{ph}: Phytoplankton absorption coefficient
a_t: Total absorption coefficient
AOP: Apparent Optical Properties
AOT: Aerosol Optical Thickness
APEX: Airborne Prism Experiment
ASD: Analytical Spectral Devices
BLI: Balaton Limnological Institute
b_{bp}: Particulate backscattering coefficient
b_p: Particulate scattering coefficient
Chla: Chlorophyll-a
c_t: Beam attenuation coefficient
c_p: Particulate beam attenuation coefficient
CASI: Compact Airborne Spectrographic Imager
CDOM: Coloured Dissolved Organic Matter
CEH: UK Centre for Ecology & Hydrology
CHRIS-PROBA: Compact High-Resolution Imaging Spectrometer on Project for On-Board Autonomy satellite
CIPEL: Commission Internationale pour la Protection des Eaux du Léman
COD: Chemical Oxygen Demand
CORPI: Klaipeda University Coastal Research and Planning Institute
CNR-IREA: Italian National Research Council - Institute for the Electromagnetic Sensing of the Environment
DLS: Department of Life Sciences
DMR: Department of Marine Research
DOC: Dissolved Organic Carbon
Eawag: Aquatic Research Institute, Switzerland
E_d: Downwelling solar irradiance
ELISA: Enzyme-Linked ImmunoSorbent Assay
EOMAP: Aquatic Earth Observation and Mapping
EPA: Environmental Protection Agency
EPFL: École Polytechnique Fédérale de Lausanne
ESA: European Space Agency
ETM+: Enhanced Thematic Mapper Plus

EUAB: End-User Advisory Board
EUFAR: European Facility for Airborne Research
FR: Full Range
GLaSS: Global Lake Sentinel Services (EU FP7 project)
f_{CDOM}: CDOM fluorescence
HH: Handheld
HICO: Hyperspectral Imager for the Coastal Ocean
HPLC: High Performance Liquid Chromatography
INFORM: Improved Monitoring and Forecasting of Ecological Status of European Inland Waters by Combining Future Earth Observation Data and Models
ISF: Lake Research Institute of the Environmental Agency Baden-Württemberg
IOP: Inherent Optical Properties
JRC: Joint Research Centre
KdKVI: Central Transdanubian (Regional) Inspectorate for Environmental Protection, Nature Conservation and Water Management
KU: Klaipeda University
LiDAR: Light Detection and Ranging
LIMNADES: Lake Bio-optical Measurements and Matchup Data for Remote Sensing
LOV: Laboratoire d'Océanographie de Villefranche-sur-Mer
L_u: Upwelling water-leaving radiance
MAGEST: MArel Gironde ESTuary
MERIS: MEdium Resolution Imaging Spectrometer
MIVIS: Multispectral Infrared Visible Imaging Spectrometer
MODIS: Moderate Resolution Imaging Spectroradiometer
MOSS: Microsoft Office Sharepoint Server
NAP: Non-Algal Particles
NASA: National Aeronautics and Space Administration
NERC: UK Natural Environment Research Council
NERC ARSF: UK NERC Airborne Research and Survey Facility
OLI: Operational Land Imager
PAR: Photosynthetically Active Radiation
PC: Phycocyanin
PE: Phycoerythrin
PI: Principal Investigator
PML: Plymouth Marine Laboratory
POC: Particulate Organic Carbon
RBINS: Royal Belgian Institute of Natural Sciences

Rrs: Remote sensing reflectance

Rw: Water-leaving reflectance

SWIR: Short-Wave Infrared

TOC: Total Organic Carbon

TSM: Total Suspended Matter

UKLEON: United Kingdom Lake Ecological Observatory Network

ULM: Ultra Light Motorised

USGS: United States Geological Survey

USTIR: University of Stirling

VITO: Flemish Institute for Technological Research

VMM: Flemish Environment Agency

VNIR: Visible and Near-InfraRed

WISP-3: Water Insight spectrometer with 3 radiometers

EXECUTIVE SUMMARY

The INFORM project will develop new or improved inland water quality products for application to the new generation of high spatial and/or spectral resolution satellite sensors and use these products to better parameterize and validate lake ecosystem models. This report documents the existing datasets for algorithm development and validation available to the INFORM project for the European study sites currently considered in the project tasks. The availability of data on the in-situ inherent optical properties (IOPs), apparent optical properties (AOPs), biogeochemical constituents and aerosol optical thickness is catalogued for each study site. In addition, all existing airborne and spaceborne datasets held by INFORM project partner are also listed in full. The availability of each dataset for use by project partners is indicated and contact details for data access are provided. Finally, an analysis of the main data gaps is performed and is provided based on the data needs indicated by INFORM project partners.

1. Introduction

The test sites selected by the INFORM partner institutions for inclusion in the project are listed in *Table 1* and shown in *Figure 1*. The sites encompass a large variety of European inland waters including deep oligotrophic lakes, shallow eutrophic lakes, coastal lagoons and turbid rivers. These specific sites were selected on the basis that they cover a range of optical water types and have very good existing in-situ and remote sensing data (airborne and/or satellite) available to facilitate algorithm development and validation work in INFORM.

Table 1. Overview of INFORM sites with their main characteristics. †Lake Geneva was added to the INFORM sites after discussions at the INFORM End-User Advisory Board meeting (EUAB01), Venice, March 2014.

Site	Country	Characteristic
Lake Balaton	Hungary	Largest lake in Central Europe, shallow and meso-eutrophic
Kis-Balaton	Hungary	Hypereutrophic water reservoir system
Curonian lagoon	Lithuania	Hypereutrophic coastal lagoon
Mantua Lakes	Italy	Small and shallow artificial eutrophic basins
Lagoon of Venice	Italy	Turbid coastal lagoon
Lake Constance	Germany, Switzerland, Austria	Meso-oligotrophic lake
Lake Geneva (Lac Lémen)†	Switzerland, France	Meso-oligotrophic lake
Gironde river	France	Highly turbid river
Scheldt river	Belgium	Highly turbid river
Esthwaite Water	UK	Small, monomictic eutrophic lake
Loch Lomond	UK	Warm, monomictic; oligotrophic in northern basin, mesotrophic in southern basin
Loch Leven	UK	Shallow, polymictic eutrophic shallow lake
IJsselmeer	The Netherlands	Eutrophic, largest freshwater lake in northwestern Europe; Markermeer is a turbid lake.

Figure 1. The location of the INFORM European study sites.

Several INFORM partners acquired data (in-situ and/or airborne hyperspectral and/or spaceborne) prior to the start of the INFORM project. This report provides an overview of the datasets that are available at the INFORM partner organizations for use within the project. Indication is given if the data can be used by other INFORM partners in the framework of the INFORM project. The relevant contact person for data access and for data policy (if available) is also provided for each dataset.

2. Lake Balaton and Kis-Balaton

2.1. Site description

Lake Balaton is the largest lake in central Europe with a surface area of 592 km^2. The lake is very shallow, with a mean depth of approximately 3.3 m and a maximum depth of 25 m. The lake is comprised of four main basins (from west to east): Keszthely; Szigliget; Szemes; and Siofok. The main inlet into the lake is the River Zala in the westernmost part of the Keszthely basin, and the only outlet is through the Siofuk canal in the east. Lake Balaton's large surface area, allied to its shallow depth, result in it being well mixed and non-stratifiying. During windy periods, intense resuspension of bottom sediments can occur.

The lake has historically suffered from eutrophication due to high inputs of nutrients from agricultural land entering the lake via the River Zala. Until recently, the Keszthely and Szigliget basins were eutrophic with high cyanobacterial biomass during summer months. In comparison, the Siofuk basin has always been more nutrient poor and less productive. Due to recent reductions in the nutrient load the water quality in the western basins has improved considerably and phytoplankton biomass has decreased substantially. The lake also receives high inputs of coloured dissolved organic matter (CDOM) from the River Zala, with very high but localized concentrations in the Keszthely basin.

Kis-Balaton is a large, hypertrophic shallow water reservoir system constructed to the south west of Lake Balaton. The system extends to about 76 km^2 encompassing open water (some 28 km^2) and wetland habitats. The mean depth of the open water is typically about 1m. The system was constructed to reduce the external loading of nutrients and sediment in Lake Balaton from the River Zala.

2.2. Monitoring data

Data from long-term monitoring programmes led by the Balaton Limnological Institute (BLI) and the Central Transdanubian (Regional) Inspectorate for Environmental Protection, Nature Conservation and Water Management (KdKVI) are available to the project for WP5 and WP6. The long-term monitoring programmes involve the collection of in-situ measurements and water samples at 4-5 stations on Lake Balaton approximately every fortnight during ice-off conditions. The key parameters measured include (length of record): phytoplankton counts (1965-), Chla (1975-), TSM (c. 2000-), DOC (1995-) and nutrients (c. 2000-). The BLI data are from depth-integrated water samples, whereas the KdKVI data are from surface samples (upper 0.5 m).

Data contact
Dr Mátyás Présing, Balaton Limnological Institute, presing.matyas@okologia.mta.hu

2.3. Campaign data

USTIR have undertaken two sampling campaigns in Lake Balaton during August 2010 and 2013 during which airborne hyperspectral data, optical data and in-situ water quality data were collected. These data are also available to the project for WP5 and WP6. These campaigns included measurement of IOPs, AOPs, water constituents concurrent to airborne and satellite overpasses. An overview of these data is provided in *Table 2* and *Table 3* for the years 2010 and 2013 respectively.

Data contact
Dr Peter Hunter, University of Stirling, p.d.hunter@stir.ac.uk

Table 2. Overview of data collected at Lake Balaton and Kis-Balaton in 2010 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla PC Photopigments TSM CDOM DOC Primary production Phytoplankton biomass	Spectrophotometric Spectrophotometric HPLC Gravimetric Spectrophotometric TOC analyser 14C uptake Microscopy	38 stations	19-25 August 2010	USTIR & PML
In-situ and laboratory IOPs	a_t, a_p, a_{CDOM} c_t, c_p b_{bp} a_{ph}, a_{NAP} a_{CDOM}	Wetlabs AC-S Wetlabs AC-S Wetlabs BB3 Filter-pad method Spectrophotometric	35 stations	19-25 August 2010	USTIR & PML
In-situ AOPs	$R_{rs}(0+)$	Satlantic HyperSAS	38 stations	19-25 August 2010	USTIR & PML
Atmospheric	AOT	Microtops II	Concurrent to airborne data	19-25 August 2010	USTIR & PML
Airborne	Hyperspectral AISA Eagle and Hawk data GRIMM Sky OPC aerosol spectrometer (particle size distribution) Leica ALS50 LiDAR		Full coverage (5 m pixels)	19-25 August 2010	USTIR, PML & NERC ARSF

Spaceborne	MERIS FR data	1 image	22 August 2010	USTIR, PML & ESA

Table 3. Overview of data collected at Lake Balaton in 2013 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla PC TSM CDOM DOC POC Phytoplankton counts	Spectrophotometric Spectrophotometric Gravimetric Spectrophotometric Shimazdu analyser Carlo-Erba analyzer Microscopy	13 stations	10-17 August 2013	USTIR
In-situ and laboratory IOPs	a_t, a_p, a_{CDOM} c_t, c_p b_{bp} a_{ph}, a_{NAP} a_{CDOM} f_{CDOM}	Wetlabs AC-S Wetlabs AC-S Wetlabs BB3 Filter-pad method Spectrophotometric EEM fluometer	13 stations	10-17 August 2013	USTIR
In-situ AOPs	R_{rs}(0+)	Satlantic HyperSAS	13 stations	10-17 August 2013	USTIR
Spaceborne	Landsat-7 ETM+		1 image	16 August 2013	USTIR & USGS

3. Curonian lagoon

3.1. Site description

The Curonian Lagoon is the largest lagoon in Europe, extending over about 1560 km^2 between Lithuania and the Russian Federation. It is physically separated from the Baltic Sea by a narrow strip of land called the Curonian Spit but maintains a hydrological connection via the Klaipeda Strait. The northern part of the lagoon is a transitional riverine-like system, while the southern part is lacustrine with limited water exchange and lower current velocities. The Curonian Lagoon is considered to be a freshwater system with an average annual salinity ranging from 2.6% at the inlet connecting it to the sea to 1.2% in the northern part and 0.1% in the central area. The Nemunas River is the main input into the system.

The lagoon is very shallow and readily mixed by wind action, although weak stratification can occur temporarily during the summer. The system is also highly eutrophic due to external nutrient loads received via the Nemunas River. Consequently, the lagoon is highly turbid due to the wind-driven resuspension of bottom sediments in shallow waters and intensive primary production. Diatoms blooms (mainly *Stephanodiscus hantzschii*) occur in the spring, but are replaced by cyanobacteria during summer months (mainly *Aphanizomenon flos-aquae and Microcystis aeruginosa*). Macrophytes are largely confined to the littoral zone.

3.2. Monitoring data

Data from long-term monitoring program led by the Department of Marine Research (DMR) of Environmental Protection Agency of Lithuania (EPA) are available to the project for WP5 and WP6. The existing national monitoring system in the Lithuanian part of the Curonian Lagoon involves the collection of in-situ measurements and water samples at 10-14 stations located in the Klaipeda Strait, within the inner part of the lagoon, and in the mouth of the Nemunas River. Sampling is conducted approximately every month. The key parameters measured include (length of record): meteorological (temperature, wind speed and direction, humidity etc.) and hydrological (water temperature, salinity, currents direction and speed, transparency (Secchi disk depth) and colour, pH (since 1954 –); dissolved oxygen concentration (since 1961 –); nutrients (since 1967-1979 –); phytoplankton species composition, abundance and biomass (since 1980 –); chlorophyll a concentration (since 1983 –); TSM (c. since 1999 –). Samples are taken from the surface (upper 0.5 m).

Data contact
Diana Vaičiūtė, CORPI KU, diana.vaiciute@jmtc.ku.lt.

3.3. Campaign data

The Coastal Research and Planning Institute (CORPI) of Klaipeda University (KU) together with Optical Remote Sensing Group at CNR-IREA have undertaken several field campaigns in the Curonian Lagoon during

spring and summer 2009, summer 2011 and 2012 during which optical data and in-situ water quality data were collected (*Table 4*,*Table 5,* and *Table 6*).

Data contact

Mariano Bresciani, Optical Remote Sensing Group, CNR-IREA, Italy, bresciani.m@irea.cnr.it,
Claudia Giardino, Optical Remote Sensing Group, CNR-IREA, Italy, giardino.c@irea.cnr.it
Diana Vaičiūtė, CORPI KU, diana.vaiciute@jmtc.ku.lt.

Table 4. Overview of data collected in the Curonian Lagoon in 2009 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation(s)
In-situ water constituents	Chla CDOM Phytoplankton counts Phytoplankton groups	Spectrophotometric Spectrophotometric Microscopy Fluorescence	27 stations	23-26 March 2009, 22 July 2009	CNR-IREA & CORPI
In-situ and laboratory IOPs	a_{ph}, a_{NAP} a_{CDOM}	Filter-pad absorption Spectrophotometric	27 stations	23-26 March 2009, 22 July 2009	CNR-IREA, CORPI
In-situ AOPs	$R_{rs}(0+)$, $R(0-)$	ASD-FR	27 stations	23-26 March 2009, 22 July 2009	CNR-IREA, CORPI
Spaceborne	MERIS FR data		2 images	23-26 March, 22 July 2009	CNR-IREA, CORPI, ESA

Table 5. Overview of data collected in the Curonian Lagoon in 2011 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation(s)
In-situ water constituents	Chla CDOM	Spectrophotometric Spectrophotometric	10 stations	4 July 2011	CNR-IREA & CORPI

	Phytoplankton counts Phytoplankton groups	Microscopy Fluorescence			
In-situ and laboratory IOPs	a_{ph}, a_{NAP} a_{CDOM}	Filter-pad absorption Spectrophotometric	10 stations	4 July 2011	CNR-IREA, CORPI
In-situ AOPs	$R_{rs}(0-)$, $R(0-)$	ASD-FR	10 stations	4 July 2011	CNR-IREA, CORPI

Table 6. Overview of data collected in the Curonian Lagoon in 2012 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation(s)
In-situ water constituents	Chla CDOM Phytoplankton counts Phytoplankton groups	Spectrophotometric Spectrophotometric Microscopy Fluorescence	7 stations	29-30 July 2012	CNR-IREA & CORPI
In-situ and laboratory IOPs	a_{ph}, a_{NAP} a_{CDOM} b_{bp}	Filter-pad absorption Spectrophotometric HOBI Labs Hydroscat-6	7 stations	29-30 July 2012	CNR-IREA & CORPI
In-situ AOPs	$R_{rs}(0+)$, $R(0-)$ $R_{rs}(0+)$	ASD-FR WISP-3	7 stations	29-30 July 2012	CNR-IREA & CORPI
Spaceborne	CHRIS-PROBA		1 image	3 August 2012	CNR-IREA & ESA

4. Mantua Lakes

4.1. Site description

The Mantua Lakes are a chain of three shallow eutrophic lakes near the town of Mantua in northern Italy. They are fluvial lakes formed from a meander of the Mincio River that was dammed in the 12th century. The water level is artificially regulated by the Vasarone Dam. The lakes are nutrient enriched, highly productivity and generally turbid. The phytoplankton community is typical of eutrophic and/or hypertrophic systems rich with diatoms dominant in spring, and cyanophytes and chlorophytes dominate in summer. Floating-leaved macrophytes (especially *Nelumbo nucifera*) form extensive meadows from late April to September.

4.2. Monitoring data

Data from monitoring program (2006-2013) led by the Department of Life Sciences of the University of Parma (DLS) are available to the project for WP5 and WP6. The data series of monitoring program operated by DLS involve the collection of in-situ measurements and water samples at 3 stations on Mantua Lakes. Monitoring data were collected in February and March 2006 and May 2008. Data were measured every 4 hours in a 24 hours cycle monthly between January and December 2007. Seasonal data were measured from April 2011 and March 2013. The key parameters measured include: oxygen, pH, temperature, conductivity, dissolved inorganic carbon, methane, dissolved inorganic nitrogen (ammonium, nitrite, nitrate), soluble reactive phosphorous, total nitrogen and phosphorous (dissolved and particulate forms), dissolved silica, COD, *Escherichia coli*, chlorophyll-a, total suspended matter. During the vegetative period of 2007 and 2008, and from 2011 to 2013, DLS characterized the macrophyte communities of the Mantua Lakes and collected macrophytes samples (i.e *Trapa natans*, *Nelumbo nucifera*) for biomass estimation, C:N content (leaf and roots), and measures of plant structure.

Data contact
Monica Pinardi, CNR-IREA and University of Parma, pinardi.m@irea.cnr.it

4.3. Campaign data

CNR-IREA have undertaken some sampling campaigns in Mantua Lakes during summer 2007, 2010 and 2011 during which airborne and satellite hyperspectral data, optical data and in-situ water quality data were collected. These data are also available to the project for WP5 and WP6. An overview of the in-situ, airborne and spaceborne data is provided in *Table 7, Table 8* and *Table 9* below for the years 2007, 2011 and other data respectively. Furthermore, CNR-IREA has collected in-situ reflectance data for macrophyte species (included in *Table 7*).

Data contact
Mariano Bresciani, Optical Remote Sensing Group, CNR-IREA, Italy, bresciani.m@irea.cnr.it,
Claudia Giardino, Optical Remote Sensing Group, CNR-IREA, Italy, giardino.c@irea.cnr.it

Table 7. Overview of data collected at Mantua lakes in 2007 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation(s)
In-situ water constituents	Chla TSM	Spectrophotometric Gravimetric	13 stations	29 June and 26 July 2007	CNR-IREA
In-situ AOPs	$R_{rs}(0+)$, $R(0-)$	ASD-FR	13 stations	29-30 July 2007	CNR-IREA
Atmospheric	AOT	EKO MS-120	1 station	26 July 2007	CNR-IREA
Airborne	MIVIS (VNIR)		5 m pixels	26 July 2007	CNR-IREA
In-situ AOPs macrohytes	$R(0+)$	Field ASD-FR	15 sites, 6 species	07 May 2007, 29 June 2007 and 26 July 2007	CNR-IREA

Table 8. Overview of data collected at Mantua lakes in 2011 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla TSM CDOM Chla, PC, PE Phytoplankton counts	Spectrophotometric Gravimetric Spectrophotometric In-situ fluorescence Microscopy	35 stations	6-29 Sept 2011	CNR-IREA
In-situ / laboratory IOPs	a_{ph}, a_{NAP} a_{CDOM}	Filter-pad absorption Spectrophotometric	26 stations	6-29 Sept 2011	CNR-IREA
In-situ AOPs	$R_{rs}(0+)$, $R(0-)$	ASD-FR	13 stations	6-29 Sept 2011	CNR-IREA

Atmospheric	AOT	EKO MS-120	1 station	21 Sept 2011	CNR-IREA
Airborne	APEX (VNIR)		5 m pixels	21 Sept 2011	CNR-IREA

Table 9. Overview of other data collected at Mantua Lakes available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla TSM CDOM	Spectrophotometric Gravimetric Spectrophotometric	9 stations	19 July 2010 and 9 August 2010	CNR-IREA
In-situ / laboratory IOPs	a_{ph}, a_{NAP} a_{CDOM} b_{bp}	Filter-pad absorption Spectrophotometric HOBI Labs Hydroscat-6	6 stations	6-29 Sept 2011	CNR-IREA
In-situ AOPs	$R_{rs}(0+)$, $R(0-)$	ASD-FR	9 stations	6-29 Sept 2011	CNR-IREA
Spaceborne	CHRIS-PROBA (VNIR)			29 June 2008 and 16 August 2008, 28 August 2011, 6 August 2012	CNR-IREA & ESA

5. Venice lagoon

5.1. Site description

The Venice Lagoon at ~550 km^2 is the largest shallow coastal lagoon in the Mediterranean. It maintains a connection to the Adriatic Sea through the inlets of Lido, Malamocco, and Chioggia. The Lagoon has an average water depth of about 1.1 m and a maximum tidal range of about 1.5 m, with a main period of about 12 h. The majority of the lagoon is comprised of shallow water, mud flats and saltwater marshes. The lagoon has been subject to intense anthropogenic pressure over the past few decades from hydrological modification resulting from flood defence works and eutrophication. Key ecological impacts include the extensive loss of benthic seagrass cover.

5.2. Monitoring data

Data from long-term monitoring projects of seagrasses distribution are reported in technical reports available to the project for WP5 and WP6. The long-term monitoring programmes were led by local authorities with the aim of mapping the three species of seagrasses, which colonized the Venice Lagoon. The results are represented by seasonal distribution of seagrass, based on "traditional" in-situ surveys. These maps will be available for the validation of Earth observation products.

Data contact
Federica Braga, Institute of Marine Sciences, f.braga@ismar.cnr.it

5.3. Campaign data

CNR has undertaken sampling campaigns in Venice Lagoon from 2002 during which airborne and satellite hyperspectral data, optical data and in-situ water quality data were collected. These data are also available to the project for WP5 and WP6. The sampling campaigns operated by CNR have involved two different approaches:

(1) the collection of radiometric measurements for a spectral characterization of seagrasses, with different tidal levels. They were undertaken in 2002, 2003 and 2011.

(2) IOP and AOP in-situ measurements and water samples in deep optical water, undertaken in 2001 and 2005, during airborne and satellite overpasses.

An overview of the in-situ, airborne and spaceborne data is provided in *Table 10* and *Table 11*. Other IOP and AOP in-situ measurements and water samples in optically deep waters were undertaken by CNR in 2011 and 2012.

Data contact
Federica Braga, Institute of Marine Sciences, f.braga@ismar.cnr.it.
Mariano Bresciani, Optical Remote Sensing Group, CNR-IREA, Italy, bresciani.m@irea.cnr.it.

Table 10. Overview of data collected at Venice Lagoon in 2005 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla Chla TSM CDOM	Spectrophotometric HPLC Gravimetric Spectrophotometric	12 stations	23-25 May 2005	CNR-IREA
In-situ / laboratory IOPs	a_t c_t b_{bp} a_{ph}, a_{NAP} a_{CDOM}	Wetlabs AC-9 Wetlabs AC-9 HOBI Labs Hydroscat-6 Filter-pad method Spectrophotometric	12 stations	23-25 May 2005	CNR-IREA
In-situ AOPs	L_u, E_d $R_{rs}(0+)$	ASD-FR SpectraScan PR-650	12 stations	23-25 May 2005	CNR-IREA
Atmospheric	AOT	CIMEL (AERONET)	2 stations	23-25 May 2005	CNR-ISMAR and JRC
Airborne	Hyperspectral CASI (VNIR)		6 m pixels	25 May 2005	CNR
Spaceborne	CHRIS-PROBA (VNIR)			29 June 2008 and 16 August 2008, 28 August 2011, 6 August 2012	CNR-IREA & ESA

Table 11. Overview of data collected at Venice Lagoon for seagrass spectral characterization available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water	Turbidity	Turbidity	7 stations	Apr–Oct	CNR-IREA

constituents		meter		2002; Apr-Sep 2003 Nov 2011	
In-situ AOPs	$R_{rs}(0+)$	SpectraScan PR-650	7 stations, repeated every month with hourly measurements	Apr–Oct 2002; Apr-Sep 2003 Nov 2011	CNR-IREA
Spaceborne	Landsat 7 Ikonos Geo-eye Quickbird Pléiades (not synchronous)			Apr–Oct 2002; Apr-Sep 2003 Nov 2011	CNR-IREA & ESA

Table 12. Overview of data collected at Venice Lagoon in 2011-2012 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla TSM CDOM	Spectrophotometric Gravimetric Spectrophotometric	18 stations	27-28 Oct 2011 23-24 July 2012	CNR-IREA and Klaipeda University
In-situ / laboratory IOPs	b_{bp} a_{ph}, a_{NAP} a_{CDOM} Particle size distribution and volume concentration	HOBI Labs Hydroscat-6 Filter-pad method Spectrophotometric LISST-100X	18 stations	27-28 Oct 2011 23-24 July 2012	CNR-IREA and Klaipada University
In-situ AOPs	$R_{rs}(0+)$ $R_{rs}(0+)$	SpectraScan PR-650 WISP-3	18 stations	27-28 Oct 2011 23-24 July 2012	CNR-IREA and Klaipeda University
Atmospheric	AOT	CIMEL (AERONET)	1 station	27-28 Oct 2011 23-24 July 2012	JRC, CNR-IREA and Klaipeda University

6. Lake Constance

6.1. Site description

Lake Constance is the second largest lake in Western Europe with a surface area of approximately 535 km^2. It is located at 395 m a.s.l. and has a mean and maximum depth of 101 m and 253 m, respectively. The Alpenrhein River is the main inlet, accounting for 62% of the total inflow. Lake Constance is naturally an oligotrophic system, but increased nutrient inputs led to eutrophication of Lake Constance in the late 1970s. The lake has since undergone 20 years of nutrient reduction and has returned to oligotrophic status. Phytoplankton chlorophyll-a concentrations peak during the diatom-dominated spring bloom (approximately 10 mg m^{-3}) but are otherwise relatively low (approximately 1 mg m^{-3} in winter and 3-5 mg m^{-3} in summer through autumn).

6.2. Available data

Datasets have been already generated in the frame of the FP7 FRESHMON project (www.freshmon.eu) for Lake Constance. These datasets were acquired during several field campaigns in 2012. The in-situ measurements (WISP-3, water constituents, etc.) were conducted commonly by Eawag and ISF. EOMAP processed the satellite data. In addition, a publication by Pitarch et al. 2014 presents the results of retrieved in-situ suspendend matter and Rrs for 18 stations over a stepwise depth profile from 0 to 20m. The published data can be used as validation source for the stratification algorithm (upon approval of the data owners). Further vertical profile data measured provided by the Lake Research Institute of the Environmental Agency Baden-Württemberg (ISF) have been requested but not yet confirmed.

Data contact
Karin Schenk, EOMAP, schenk@eomap.de (data policy for in-situ data according to user practice)

Table 13. Overview existing and to be used data for Lake Constance available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Date	Host organisation	Availability
Spaceborne	RapidEYE	3-4 May 2012	EOMAP	Yes
	MODIS Aqua and Terra	25 May 2012	EOMAP	Yes
	Landsat-8 OLI Landsat-7 ETM+	Selected dates*	EOMAP	Yes
	MODIS Aqua and Terra	Selected dates*	EOMAP	Yes
In-situ (routine monitoring program)	Turbidity vertical profiles	To be defined	ISF	Unclear, data request ongoing
In-situ	Vertical profiles of TSM	25 May 2012	Eawag	Only upon approval

(campaign-based)	and $R_{rs}(0+)$			of the data owner

* Selection will be made according to data monitored by the ISF

7. Gironde River

7.1. Site description

The Gironde Estuary, southwest France, is one of the largest estuaries on the European Atlantic coast. It is characterised by a well-developed turbidity maximum and very high TSM that can range from 150 to approximately 3000 mg/L in near surface waters.

7.2. Monitoring

Since 2004, the MAGEST (MArel Gironde ESTuary) monitoring network, provides real-time, continuous measurements of the water quality of the Gironde estuary, based on four automated stations. There is one station at Pauillac which measures turbidity in NTU. There is a restricted data policy. In order to use the data it is necessary to obtain an agreement with the researchers of MAGEST. For more information see:

H. Etcheber, S. Schmidt, A. Sottolichio, E. Maneux, G. Chabaux, J.-M. Escalier, H. Wennekes, H. Derriennic, M. Schmeltz, L. Quéméner, M. Repecaud, P. Woerther, and P. Castaing, 2011, Monitoring water quality in estuarine environments: lessons from the MAGEST monitoring program in the Gironde fluvial-estuarine system, Hydrol. Earth Syst. Sci., 15, 831-840.

7.3. Campaigns

VITO has undertaken two sampling campaigns in the Gironde estuary in June 2012 and August 2013. In-situ measurements were collected on fixed pontoons and on a vessel. In addition hyperspectral airborne data were collected in 2012. Additional monitoring data is available from MAGEST (MArel Gironde ESTuary), but with a restricted data policy. An overview of the in-situ, airborne and spaceborne data is given below for the year 2012 and 2013.

Data contact
Els Knaeps, VITO, els.knaeps@vito.be

*Table 14. Overview of data collected at Gironde River in 2012 for use in WP5, Task 5.3 (*denotes data only available for use by other INFORM partners after approval by the host organization).*

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla TSM Turbidity	HPLC Gravimetric HACH 2100P ISO turbidimeter	45 stations	11-16 June 2012	VITO, LOV*
In-situ /	a_{ph}, a_{NAP}	Filter-pad method	45 stations	11-16 June	LOV, RBINS*

laboratory IOPs	a_{CDOM} b_{bp}	Spectrophotometric BB3		2012	
In-situ AOPs	$R_w(0+)$ $R_w(0+)$	TriOS RAMSES ASD FR	45 stations	11-16 June 2012	VITO, RBINS*
Airborne	APEX (VNIR-SWIR)		Part of the width of the estuary from Blaye to mouth	14 June 2012	VITO

*Table 15. Overview of data collected at Gironde River in 2013 for use in WP5, Task 5.3 (*denotes data only available for use by other INFORM partners after approval by the host organization).*

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	TSM Turbidity	Gravimetric HACH 2100P ISO turbidimeter	27 stations	12-16 August 2013	VITO, LOV*
In-situ / laboratory IOPs	a_t b_{bp} b_{bp}	Wetlabs AC-9 Wetlabs BB3 HOBI Labs Hydroscat-4	27 stations	12-16 August 2013	LOV, RBINS*
In-situ AOPs	$R_w(0+)$ $R_w(0+)$	TriOS RAMSES ASD FR	27 stations	12-16 August 2013	VITO, RBINS*

8. Scheldt River

VITO has undertaken four sampling campaigns in the Scheldt river in June 2010, October 2010 and June 2012. In-situ measurements were collected on a fixed pontoon. In addition, hyperspectral airborne data were collected in 2012.

8.1. Site description

The Scheldt River rises in Northern France and flows through Belgium and the Netherlands to the North Sea. The river is rain-fed and the average discharge varies considerable between summer-autumn (60 m^3/s) and winter-spring (180 m^3/s). The Scheldt River is highly turbid with TSM concentrations in excess of 50 mg/L in near surface waters. However, TSM concentrations are highly variable and respond to tidal and season cycles. The tide regime is semi-diurnal and its influence extends 82 km upstream as far as Ghent. The mud in the Scheldt Estuary is derived from both marine and terrestrial sources. The terrestrial sources include waste water, soil surface erosion, erosion of the exposed clay layers at the bottom of the estuary, and precipitation. Chlorophyll-a concentrations are typically 10-20 mg m^{-3} but can exceed 100 mg m^{-3} during summer phytoplankton blooms.

8.2. Monitoring

There are limited additional monitoring data available from the Flemish Environment Agency (VMM). The Flemish Environment Agency (VMM) has a water monitoring network in place. One of the stations is situated in the INFORM study area of the Scheldt river. One of the parameters that are being measured is the TSM concentration. However data has not been collected continuously. The VMM provides a webservice to view the data that have been collected at the various stations (http://geoloket.vmm.be/Geoviews/).

8.3. Campaigns

VITO has undertaken four sampling campaigns in the Scheldt river in June 2010, October 2010 and June 2012. In-situ measurements were collected on a fixed pontoon. In addition, hyperspectral airborne data were collected in 2012. An overview of the in-situ, airborne and spaceborne data is given below for the year 2010 and 2012.

Data contact
Els Knaeps, VITO, els.knaeps@vito.be

*Table 16. Overview of data collected at Scheldt river in 2010 for use in WP5, Task 5.3 3 (*denotes data only available for use by other INFORM partners after approval by the host organization).*

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla TSM Turbidity	HPLC Gravimetric HACH 2100P ISO turbidimeter	45 stations	11-16 June 2010	VITO, LOV*
In-situ / laboratory IOPs	a_{ph}, a_{NAP} a_{CDOM} b_{bp}	Filter-pad method Spectromphotometric BB3	45 stations	11-16 June 2010	LOV, RBINS*
In-situ AOPs	$R_w(0+)$ $R_w(0+)$	TriOS RAMSES ASD FR	45 stations	11-16 June 2010	VITO, RBINS*

*Table 17. Overview of data collected at Scheldt river in 2012 for use in WP5, Task 5.3 3 (*denotes data only available for use by other INFORM partners after approval by the host organization).*

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla TSM Turbidity	HPLC Gravimetric HACH 2100P ISO turbidimeter	45 stations	11-16 June 2012	VITO, LOV*
In-situ / laboratory IOPs	a_{ph}, a_{NAP} a_{CDOM} b_{bp}	Filter-pad method Spectromphotometric BB3	45 stations	11-16 June 2012	LOV, RBINS*
In-situ AOPs	$R_w(0+)$ $R_w(0+)$	TriOS RAMSES ASD FR	45 stations	11-16 June 2012	VITO, RBINS*
Airborne	APEX (VNIR-SWIR)		Scheldt between Antwerp city and Lillo	14 June 2012	VITO

9. Esthwaite Water

9.1. Site description

Esthwaite Water is a small (1.13 km^2), productive monomitic lake in the English Lake District. It has a mean depth of 6.4 m and a maximum depth of approximately 25 m. The lake is eutrophic and receives nutrients from a local sewage treatment works and fish farm. The spring bloom is typically dominated by diatoms, although cyanobacterial blooms can also occur during unseasonally warm weather. During summer, dense cyanobacterial blooms composed of genera such as *Anabaena*, *Aphanizomenon* and *Microcystis* often occur.

9.2. Monitoring data

Esthwaite Water is monitored fortnightly by the NERC Centre for Ecology & Hydrology (CEH) (Lancaster). In addition, as part of the UKLEON network, an automatic monitoring buoy records basic limnological and meterological data (e.g., PAR, wind speed and direction, air temperature, water temperature, pH, CO_2, dissolved oxygen, chlorophyll fluorescence, phycocyanin fluorescence) at high temporal resolution. These data may be available on request from CEH subject to a data agreement.

Data contact
Professor Stephen Maberly, Lake Ecosystems Group, Centre for Ecology & Hydrology, Lancaster Environment Centre; scm@ceh.ac.uk

9.3. Campaign data

USTIR led a sampling campaign on Esthwaite Water during April 2007. These campaigns included measurement of AOPs and water constituents concurrent to airborne flights. An overview of these data is provided in *Table 18* below.

Data contact
Dr Peter Hunter, University of Stirling, p.d.hunter@stir.ac.uk

Table 18. Overview of data collected at Esthwaite Water in 2007 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla PC TSM (tbc) Microcystins	Spectrophotometric Spectrophotometric Gravimetric HPLC / ELISA	5 stations	26 April 2007	USTIR, CEH

	Phytoplankton counts	Microscopy			
In-situ AOPs	*R*(0+)	ASD FieldSpec HH	5 stations	26 April 2007	USTIR
Airborne	AISA Eagle-Hawk (VNIR-SWIR)		Full lake at 2 m pixels	26 April 2007	USTIR, NERC ARSF

10. Loch Leven

10.1. Site description

Loch Leven is the largest lake (13.3 km^2) in lowland Scotland (56°12'N, 3°22'W) with mean and maximum depths of 3.9 m and 25.2 m respectively. The lake is typically well mixed and rarely stratifies. Loch Leven has been adversely affected by nutrient inputs from domestic, agricultural and industrial sources and, while there is some evidence for recovery, cyanobacterial blooms continue to occur during summer months. These blooms are typically dominated by genera such as Anabaena, Microcystis, Snowella and Woronichinia.

10.2. Monitoring data

Loch Leven is monitored fortnightly by the NERC Centre for Ecology & Hydrology (Lancaster). In addition, as part of the UKLEON network, an automatic monitoring buoy records basic limnological data at high temporal resolution. These data may be available on request from CEH subject to a data agreement.

Data contact
Dr Laurence Carvalho, Centre for Ecology & Hydrology, Penicuik, Edinburgh; **laca@ceh.ac.uk**

10.3. Campaign data

USTIR led a sampling campaigns on Loch Leven during April and August 2007. These campaigns included measurement of AOPs and water constituents concurrent to airborne flights. An overview of the these data is provided in *Table 19* below.

Data contact
Dr Peter Hunter, University of Stirling, p.d.hunter@stir.ac.uk

Table 19. Overview of data collected at Loch Leven in 2007 available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla PC TSM (tbc) Microcystins Phytoplankton counts	Spectrophotometric Spectrophotometric Gravimetric HPLC / ELISA Microscopy	10 stations	13 April, 22 August 2007	USTIR, CEH
In-situ AOPs	*R*(0+)	ASD FieldSpec HH	10 stations	13 April	USTIR

				2007, 22 August 2007	
Airborne	AISA Eagle-Hawk (VNIR-SWIR) Itres CASI-2 (multispectral VNIR)		Full lake at 2 m pixels	13 April 2007, 22 August 2007	USTIR, NERC ARSF

11. IJsselmeer

11.1. Site description

The IJsselmeer was created after closure of a dam (the Afsluitdijk) in 1932 that resulted in a transformation of the Southern Sea (an estuary) into a freshwater lake. The main source of freshwater is the river IJssel, a tributary of the river Rhine. The IJsselmeer is a Heavily Modified Water Body according to WFD terminology. The IJsselmeer and Markermeer lakes have experienced declines in certain species of waterfowl, including diving ducks and fish-eating birds.

11.2. Monitoring data

Deltares implemented a five-year research programme to investigate the causal mechanisms of the downward trends in waterfowl, to study effective measures to counteract the downward trends and their cost, and finally to define feasible conservation goals. This programme (Autonomous Downward Trend) not only collected data on numbers of waterfowl species but also of several water quality parameters such as TSM, Chl-a, transparency and nutrients. It included two automatic monitoring buoys in the lake for several of these parameters. Rijkswaterstaat monitors their water bodies continuously, including the IJsselmeer. These data are stored in a public database (live.waterbase.nl).

11.3. Campaign description

The EU FP7 project FRESHMON produced water quality data (TSM and Chl-a) for Lake Markermeer on behalf of Deltares.

12. Lake Geneva

12.1. Site description

Lake Geneva (89 km^3, 580 km^2), the largest freshwater body in Western Europe, is still recovering from his eutrophication over the last century. The excessive load of nutrients led to a total phosphorus concentration of up to 90 μg/L in the 1980s but active restoration plans including construction of waste water treatment plants, and bans on phosphorus in textile washing products, have gradually improved the trophic status of the lake. Nowadays, the lake is back to a mesotrophic state but still far from its targeted phosphorus goal (10-15 μg/L).

12.2. Monitoring data

Since 1957, the Commission Internationale pour la Protection des Eaux du Léman (CIPEL) is coordinating the monitoring of Lake Geneva with a monthly to bi-monthly sampling period over at least two in-situ locations. Lake Geneva is continuously monitored by the CIPEL for TSM, chlorophyll-a, Secchi depth and several other water quality parameters. The data are available on request. In addition EPFL has performed in-situ radiometric and water constituents analysis on a regular basis since 2013.

12.3. Campaign data

Data from previous remote sensing campaigns conducted by EPFL and Eawag is summarised in *Table 20*.

Table 20. Overview of data collected at Lake Geneva available to the INFORM project for use in WP5 and WP6.

Data	Data specification	Method / Instrument	Coverage / Resolution	Date	Host organisation
In-situ water constituents	Chla Fluorescence TSM Turbidity DOC	Spectrophotometric WetLabs ECO-FLS Gravimetric Wetlabs C-star transmissiometer Chemiluminescence	150 stations	May, July 2013 February, March, April, May, June, September 2014	EPFL
In-situ AOPs	$R_w(0+)$	TriOS Ramses Water Insight WISP-3	150 stations	May, July 2013 February, March, April, May, June, September	EPFL

				2014	
In-situ IOPs	*a* *c* *bb*	WetLabs ac-9 WetLabs bb-3	6 stations	June 2014	USTIR
Airborne	APEX, RapidEye, Ultra Light Airplane (EPFL)			14 May 2013 ULM: May,July 2013 February, March, April, May, September 2014	
Spaceborne	HICO			19 July 2014 and 2 September 2014	

13. LIMNADES

LIMNADES (Lake Bio-optical Measurements and Matchup Data for Remote Sensing) is a community owned database of lake IOP, AOP and in-water biogeochemical constituent data for remote sensing algorithm development and validation established through the UK NERC GloboLakes project. LIMNADES data are either publicly available or available upon request from the contributor or Principal Investigator (PI). Currently, LIMANDES contains data for over 1100 lakes globally (*Figure 2*). Of these, 70 lakes have in-situ water-leaving reflectance data with measurements from over 2400 stations. IOP data are available for approximately one-quarter of these stations. Most LIMNADES datasets are available for use in the INFORM project subject to agreement with the appropriate PI. More information is provided here: http://www.globolakes.ac.uk/limnades/ and a full list of lakes with available AOP/IOP data is provided in Annex 1.

Data contact

Dr Peter Hunter, University of Stirling, p.d.hunter@stir.ac.uk
Dr Vagelis Spyrakos, , University of Stirling, evangelos.spyrakos@stir.ac.uk

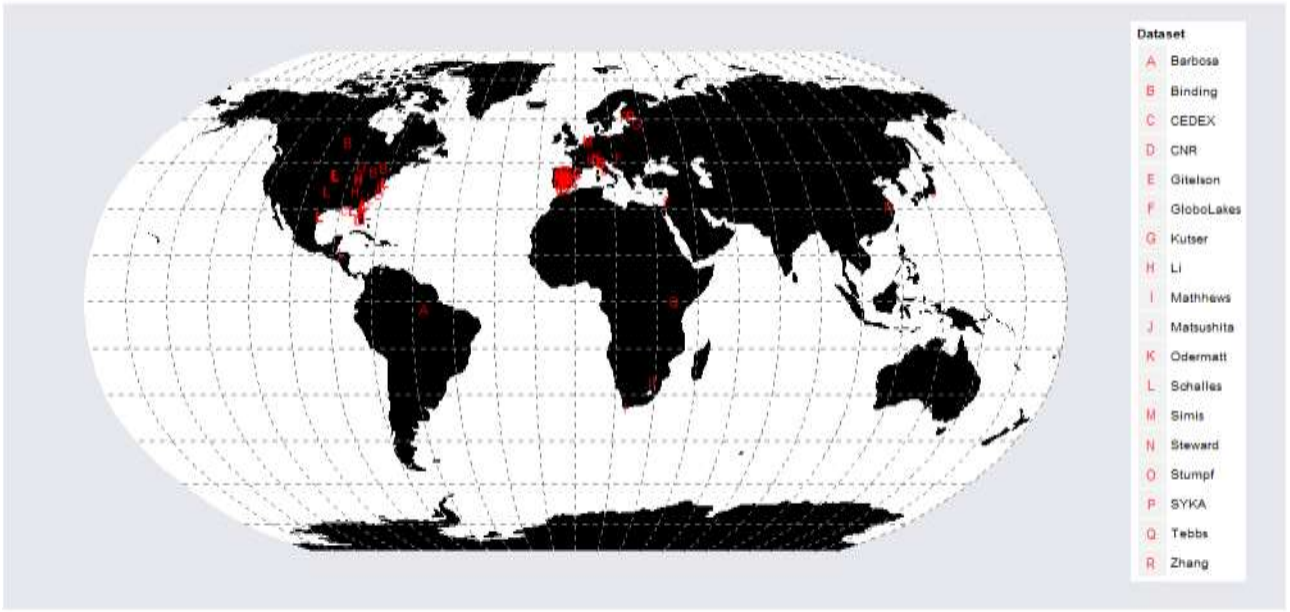

Figure 2. Geographic distribution of datasets contributed to LIMNADES. (Correct as 01 December 2014).

14. Gap analysis

Data requirements for WP5 and WP6, including in-situ IOPs, AOPs and in-water constituents, were compiled through a spreadsheet-based questionnaire completed by all partners. This is available to project partners on the INFORM MOSS portal[1]. This gap analysis is based on these requirements and the information provided in this report in relation to the existing datasets held by INFORM partners. *Table 21* provides an overview of the existing data available for use in the INFORM project for each study site.

The existing datasets held by INFORM partners encompass a wide range of water types from oligotrophic lakes, eutrophic lagoons and sediment-laden rivers and estuaries. In general, these sites encompass most of the water types highlighted by INFORM partners in regards to their requirements for WP5. In total, INFORM partners hold existing data for approximately 396 stations on the INFORM study sites. Several sites such as Lake Balaton, Curonian Lagoon and the Scheldt and Gironde estuaries have extensive existing data available. Moreover, several of these sites have complete datasets including in-situ optical data (IOPs and AOPs), in-water biogeochemical constituents and airborne/spaceborne EO data. These are high-value datasets and these will be fundamental to the algorithm development and validation tasks planned for WP5. The sections below provide a summary of the available data and an analysis of the potential gaps with respect to the data needs for the INFORM participants.

IOP and AOP datasets

In-situ IOP data are available for most lake and lagoon sites, except Lake Constance, Ijsselmeer, Esthwaite Water and Loch Leven – although IOP data for the latter site exists and will be made available via the LIMNADES database in the near future. The availability of IOP data is most limited for the oligotrophic and mesotrophic lakes, with most measurements from more eutrophic systems. However, there are additional IOP datasets potentially available through LIMNADES from more oligotrophic, clear water lakes. The Scheldt and Gironde rivers have limited IOP data and access to these can only be granted upon approval by the hosting organization, but these data are not widely. Most of the IOP data are from surface stations, with fewer measurements from depth-profiles – partly this reflects the fact that many of the data were collected in optically and/or physical shallow systems. The approaches used for the measurement of IOPs are internally consistent (i.e., within the dataset) but instruments, methods and protocols vary across sites and datasets. In-situ water-leaving reflectance data are available for all sites (and the vast majority of sampling stations) and can be used directly to develop and test algorithm and also to simulate satellite sensors. The radiometric datasets are internally consistent, but the instruments, methods and protocols vary across sites and datasets.

Biogeochemical datasets

In-situ biogeochemical are available for all lakes, this includes data collected as part of previous remote sensing campaigns and those available from long-term monitoring programmes. However, the completeness of these datasets varies between sites. Basic parameters such as TSM and Chla are available for all sites (except Lake Constance), but other parameters such as CDOM are only available for selected sites. HPLC pigments, turbidity (ISO method 7027), phytoplankton count and primary productivity data are only available for a few sites.

[1] https://esites.vito.be/sites/inform/Documents%20Exchange/WP4/T4.1%20Existing%20data%20and%20data%20gaps/D4.1%20Documentation/inform_wp5_wp6_data_requirements.xlsx

Airborne hyperspectral datasets

Eight of the eleven study sites have existing airborne multispectral or hyperspectral data available. These datasets include imagery from APEX, CASI, AISA Eagle/Hawk and the MIVIS instruments. These data are available to all INFORM project partners. In all cases, the existing airborne or hyperspectral datasets are accompanied by in-situ reflectance measurements and biogeochemical data. In addition, some are also supported by complete IOP datasets. In-situ data concurrent to the APEX data from the Scheldt and Gironde rivers are only available upon approval by the host organisation. There are concurrent AOT measurements available to support atmospheric correction studies for some but not all airborne datasets.

Satellite datasets

MERIS, MODIS and Landsat data are available for all sites and can be obtained from existing open-access archives held by ESA, NASA and the USGS. In addition, CHRIS-PROBA data are available for the Mantua Lakes and the Curonian Lagoon. RapidEye data are available for the Lake Constance and Geneva, while Ikonos
GeoEye, Quickbird and Pléiades data are available for the Venice Lagoon. HICO data are available for Lake Balaton. Many of these satellite datasets are supported by in-situ data, but the number of concurrent matchups is unknown.

Key data gaps

It is notable that most of the lakes and lagoons are turbid, eutrophic systems with high phytoplankton biomass. Data from eutrophic lakes were identified as a priority by most INFORM participants, but equally data are also required for less productive mesotrophic and oligotrophic waters and these systems are currently underrepresented in the existing data holdings. Lake Constance is oligotrophic, but it has limited existing in-situ data available compared to other sites. The recent inclusion of Lake Geneva as an additional INFORM study site will, to an extent, help to address the bias towards eutrophic systems, but other sources of data (e.g. LIMNADES, additional EUFAR campaigns) for oligo-mesotrophic waters may need to be explored to increase the data currently available to INFORM. The availability of data covering a range of inland water types and a gradient in biogeochemcial conditions (e.g., turbidity, dissolved organic carbon, phytoplankton biomass and composition) is needed to support algorithm development.

Most sites have some existing IOP data, although the completeness of these data holdings varies between sites and not all have the full suite of IOP measurements. Moreover, some of these datasets (e.g. Balaton, UK lakes) include only surface measurements and there are no data available from depth profiles – which is a requirement for WP5 Tasks 5.2 and 5.6. This may be partly explained by the fact that most of the INFORM water bodies are both physically shallow and optically shallow.

In-situ radiometric data are available for all sites, but these data are largely restricted to surface measurements. Currently, only Lake Constance has subsurface reflectance profiles (although additional data may be available from the GloboLakes project and via the LIMNADES database). Profiles of subsurface radiance/irradiance are needed for WP5 Tasks 5.1, 5.2, 5.5 and 5.7. However, such measurements may be impractical (depending on instrumentation and the means of deployment) in some of the very shallow water sites included in INFORM and might be limited to the deeper systems. Other sources of radiometric profile data (e.g. LIMNADES, additional EUFAR campaigns) may be needed to increase the data currently available.

In-situ water biogeochemical constituent data are available for all sites and most parameters indicated by INFORM participants as moderate to high priority are available for more than one of the study sites. However, HPLC pigment, turbidity (ISO method 7027), phytoplankton counts and primary productivity data required for WP5 Tasks 5.3, 5.5 and 5.8 are more scarce. This may mean that specific tasks in WP5 will be restricted to those sites with more complete data holdings.

Many sites have airborne hyperspectral data available to directly support algorithm development or for simulation of spaceborne sensors. However, as identified above, many of these existing datasets were acquired over eutrophic lakes. Currently, Lake Geneva is the only existing oligo-mesotrophic lagoon or lake with existing hyperspectral imagery.

Table 21. Summary of the existing data available to the INFORM project. (NS = not specified; BGC = biogeochemical data).

Water type	Site	Properties	Stations	In-situ data	Airborne data	Satellite data	Available to partners
Lake	Balaton	Mesotrophic	51	IOPs, AOPs, BGC	AISA Eagle-Hawk	MERIS, Landsat HICO	Yes
	Constance	Oligotrophic	NS	AOPs, BGC	None	MERIS MODIS Landsat RapidEye	Yes
	Esthwaite	Eutrophic	5	AOPs, constituents	AISA Eagle-Hawk	None	Yes
	Geneva	Mesotrophic	156	IOPs, AOPs, BGC	APEX	MERIS MODIS RapidEye	Yes
	Ijsselmeer	Eutrophic	n/a	BGC	None	MERIS MODIS	Yes
	Leven	Eutrophic	10	AOPs, BGC	AISA Eagle-Hawk, Itres CASI-2	MERIS	Yes
	Mantua	Eutrophic	57	IOPs, AOPs, BGC	MIVIS APEX	CHRIS-PROBA	Yes
Lagoon	Curonian	Eutrophic	41	IOPs, AOPs, BGC	None	MERIS CHRIS-PROBA	Yes
	Venice	Eutrophic	37	IOPs, AOPs, BGC	CASI	MERIS Landsat 7 Ikonos GeoEye Quickbird Pléiades	Yes
Estuary	Gironde	Sediment-	45	IOPs, AOPs,	APEX		Upon

		laden		BGC			approval by the host organisation
	Scheldt	Sediment-laden	45	IOPs, AOPs, BGC	APEX		Upon approval by the host organisation

15. Conclusion

The INFORM project will develop new or improved inland water quality products for application to the new generation of high spatial and/or spectral resolution satellite sensors and use these products to better parameterize and validate lake ecosystem models. The project includes two dedicated development and validation campaigns to provide data to support these tasks. In addition, all of the chosen study sites have existing in-situ and airborne and/or spaceborne remote sensing data that can be used within the project. Moreover, some sites have very comprehensive, high-value datasets encompassing in-situ IOP, AOP and biogeochemical measurements with concurrent airborne and/or spaceborne data. These datasets bring considerable added value to the project and will greatly increase the amount of data available for algorithm development and validation.

The main gaps relate to the general availability of in-situ and EO data for oligo-mesotrophic inland waters; currently most of the intensively studied sites considered in INFORM and those with the most complete datasets are eutrophic lake or lagoon systems. It is recommended that other potential sources of in-situ and EO data for inland waters, particularly for oligo-mesotrophic systems, should be investigated (e.g., external collaborators, open-access databases, or additional development campaigns). In relation to more specific data requirements, only one study site has radiometric profile data (and related IOP and biogeochemical measurements), while few sites have available HPLC pigment, turbidity, phytoplankton cell counts or primary productivity data currently available. These data needs may be addressed by the INFORM development and validation campaign but other potential sources of such data might need to be explored to ensure all tasks within WP5 and WP6 are fully supported.

Annex 1

List of lakes with IOP and AOP data available via LIMNADES.

Lake	Data availability			
	Rrs	**aph**	**aNAP**	**acdom**
Taihu	YES	YES	YES	YES
Albufera	YES	NO	NO	NO
Alcántara	YES	YES	YES	YES
Aguilar	YES	NO	NO	NO
Alarcón	YES	NO	NO	NO
Almendra	YES	YES	YES	NO
Alcorlo	YES	NO	NO	NO
El Atazar	YES	NO	NO	NO
Buendía	YES	NO	NO	NO
Beniarrés	YES	NO	NO	NO
Bornos	YES	NO	NO	NO
Burguillo	YES	NO	NO	NO
Brovales	YES	NO	NO	NO
Canelles	YES	NO	NO	NO
Cijara	YES	NO	NO	NO
Cernadilla	YES	NO	NO	NO
Contreras	YES	NO	NO	NO
Cuerda del Pozo	YES	YES	YES	YES
Cortes	YES	NO	NO	NO
Ebro	YES	NO	NO	NO
Entrepeñas	YES	NO	NO	NO
Giribaile	YES	NO	NO	NO
Guadalcacín	YES	NO	NO	NO
Guadalteba	YES	NO	NO	NO
Guadalén	YES	NO	NO	NO
Iznájar	YES	YES	YES	YES
Jándula	YES	NO	NO	NO
Sanabria	YES	NO	NO	NO
Negratín	YES	NO	NO	NO
Navalcán	YES	NO	NO	NO
Pinilla	YES	NO	NO	NO
Riaño	YES	NO	NO	NO
Rialb	YES	NO	NO	NO

Rosarito	YES	YES	YES	YES
Ricobayo	YES	NO	NO	NO
La Serena	YES	NO	NO	NO
San Juan	YES	NO	NO	NO
Santillana	YES	NO	NO	NO
Santa Teresa	YES	NO	NO	NO
Terradets	YES	NO	NO	NO
Tremp	YES	NO	NO	NO
Ullívarri	YES	NO	NO	NO
Valdecañas	YES	NO	NO	NO
Valuengo	YES	NO	NO	NO
Vega de Jabalón	YES	NO	NO	NO
Valparaíso	YES	NO	NO	NO
Valmayor	YES	NO	NO	NO
Loosdrechtse_plassen	YES	YES	YES	YES
Ijsselmeer	YES	YES	YES	YES
Peipsi	YES	YES	YES	YES
Hartbeespoort	YES	YES	YES	YES
Loskop	YES	YES	YES	YES
Theewaterskloof	YES	YES	YES	YES
Zurich	YES	NO	NO	NO
Geneva	YES	NO	NO	NO
Kasumigaura	YES	NO	NO	NO
Vesijaervi	YES	NO	NO	NO
Paeijaenne	YES	NO	NO	NO
Pyhaejaervi	YES	NO	NO	NO
Bogoria	YES	NO	NO	NO
Balaton	YES	YES	YES	YES
Garda	YES	NO	NO	NO
Mantova	YES	NO	NO	NO
Trasimeno	YES	NO	NO	NO
Idro	YES	NO	NO	NO
Maggiore	YES	NO	NO	NO
Kinneret	YES	NO	NO	NO
Fremond	YES	NO	NO	NO
EagleCreek	YES	YES	YES	YES
Geist	YES	YES	YES	YES
Morse	YES	YES	YES	YES
ACE Basin	YES	NO	NO	NO
Altamaha R	YES	NO	NO	NO

ANWR ICW	YES	NO	NO	NO
Apalach. Bay	YES	NO	NO	NO
Aransas Bay	YES	NO	NO	NO
Atlantic O.	YES	NO	NO	NO
Blackbird Creek	YES	NO	NO	NO
Canochee R.	YES	NO	NO	NO
Carter Lake	YES	NO	NO	NO
Charlotte Harb	YES	NO	NO	NO
Ches Bay	YES	NO	NO	NO
Corpus Christi	YES	NO	NO	NO
Delaware Bay	YES	NO	NO	NO
Doboy Sound	YES	NO	NO	NO
Doctors Lake	YES	NO	NO	NO
Duplin R.	YES	NO	NO	NO
GOM	YES	NO	NO	NO
Grand Bay	YES	NO	NO	NO
ICW	YES	NO	NO	NO
James River	YES	NO	NO	NO
Lake Carl Blackwell	YES	NO	NO	NO
Lake Manawa	YES	NO	NO	NO
Lake Perry	YES	NO	NO	NO
Missouri R.	YES	NO	NO	NO
Moores Lake	YES	NO	NO	NO
Murderkill R	YES	NO	NO	NO
Neuse R.	YES	NO	NO	NO
Nueces Bay	YES	NO	NO	NO
Ogeechee R	YES	NO	NO	NO
Post Office Creek	YES	NO	NO	NO
Roatan Island	YES	NO	NO	NO
Sapelo Isl	YES	NO	NO	NO
Sapelo Sound	YES	NO	NO	NO
Satilla R.	YES	NO	NO	NO
St Joe Bay	YES	NO	NO	NO
St Johns R	YES	NO	NO	NO
St Marys R	YES	NO	NO	NO
St Marys River	YES	NO	NO	NO
St. Jones R	YES	NO	NO	NO
Teakettle Creek	YES	NO	NO	NO
Venice	YES	NO	NO	NO
Winayah Bay	YES	NO	NO	NO

York River	YES	NO	NO	NO
Erie	YES	NO	NO	NO
Ontario	YES	NO	NO	NO
Winnipeg	YES	NO	NO	NO
Okeechobee	YES	NO	NO	NO
Michigan	YES	NO	NO	NO
Curuai	YES	NO	NO	NO